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SUMMARY

This report documents the results of research effort during February 1980 through May 1981 in connection with the AFOSR[redacted]. 80-0169. The research work was a continuation of earlier effort performed under AFOSR [redacted]. 77-3276. The current work consists of development of three new finite dynamic elements as well as further refinement of the associated numerical techniques pertaining to the solution of the appropriate eigenvalue problem. Together, they constitue a rather powerful tool for the efficient solution of the free vibration problem of complex practical problems.

The results of this research work will be published in journals of international standing as well as in proceedings of relevant international conferences as invited papers. Entire listing of associated computer programs will either be published in the journals or will be made available through appropriate public offices, to effect imminent transfer of new technology.

DEVELOPMENT OF FINITE DYNAMIC ELEMENTS

The formulation for the symbolic manipulation schemes pertaining to three new finite dynamic elements have essentially been completed. Thus a higher order, 8-node rectangular plane stress-strain element has been generated based on an appropriate choice of the higher order shape functions. Similar effort has been expended for the development of solid hexahedron and a solid tetrahedron element. Extensive symbolic manipulation schemes, utilizing the MIT-MACSYMA program were programmed for the development of the three elements.

Preliminary results indicate that:

1. For the same solution accuracy, the employment of finite dynamic elements effect a considerable reduction in the number of structural elements when compared with the usual finite element model. Data preparation effort is also reduced accordingly.

2. In general, the dynamic element method proves to be significantly more efficient than the usual finite element method, reducing the solution time typically by a factor between 2 and 5.

Further effort will be expended to complete the dynamic element formulation, the results of which will be published in a reputed journal (references 1, 2, and 3).

DEVELOPMENT OF A UNIFIED NUMERICAL PROCEDURE

In connection with the solution of the quadratic matrix equation associated with finite dynamic elements, the associated computer program has been further refined to yield better convergence rates for repeated and close roots. Additionally, as special cases of the unified eigenproblem solution procedure (reference 4), the associated computer program is capable to yield efficient solution of a variety of other complex practical problems, as below:

1. Buckling analysis of structures

2. Free vibration analysis of undamped structures

3. Structural free vibration analysis with viscous and/or structural damping

4. Free vibration analysis of spinning structures without or with viscous and/or structural damping.

5. Solution of simultaneous equations, real and hermitian matrices.

The associated computer program possess the following salient features:

(a) The program has been further refined to yield much faster convergence rate for close or multiple roots.

(b) As input, only the upper symmetric halves of the matrices are needed for the solution. Thus the program fully exploits matrix sparsity inherent in a discrete element idealization.

(c) The special symmetric decomposition scheme adopted earlier has been further modified to insure numerical stability during the solution process.

(d) A special shift technique has been incorporated in the program to insure effective determination of rigid body modes having 'zero' frequencies.

(e) The program enables determination of a few desired roots only, without having to compute any other.

The program has proven to be most efficient and economical for the solution of large complex problems and will further be extended for the analysis of fluid-structure interaction problems (ref. 5)

PUBLICATIONS

The following publications provide the results of research effort during the final two years of this AFOSR grant.

1. "On the Development of a Higher Order Plane Stress-Strain Finite Dynamic Element", to be submitted to the International Journal for Numerical Methods in Engineering, for publication.

2. "A Finite Dynamic Element Formulation for a Hexahedron Solid Element", International Journal for Numerical Methods in Engineering, to be published.

3. "Development of a Tetrahedron solid Finite Dynamic Element," International Journal for Numerical Methods in Engineering, to be published.

4. "Development of a Unified Numerical Procedure for free Vibration Analysis of Structures", International Journal for Numerical Methods in Engineering, Vol. 17, No. 2, 187-198, 1981.

5. "Free Vibration Analysis of Fluid-Structure Interaction Problems", invited paper to be presented at the 4th International Symposium on Finite Elements in Flow Problems, August 1982, Tokyo, Japan.

CONCLUDING REMARKS

During the first year of this new two year grant period significant advances have been made in the area of numerical analysis pertaining to structural dynamics. Thus a unified eigenproblem solution routine has been further refined for efficient solution of quadratic matrix equation associated with a finite dynamic element solution. As a spin-off, the routine is also capable of solving various free vibration problems of spinning and non spinning structures in an economical fashion. Also the formulation for three new finite dynamic elemtns has been completed, which will be further processed for achieving the final results

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